柑桔毒素病之研究※

I 外觀健全與罹病柑桔植株在墨西哥雷木及檸檬反應之異同

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一、前　言

臺灣柑桔最主要之毒素病，一般稱爲柑桔黃龍病 (Huanglungpin) 或立枯病 (Likubin) 。本病過去以爲由於果園過份潮濕所引起（3,17）。後因廣東柑桔黃龍病及南美 巴西、阿根廷等地由 Tristeza 毒素病原導致之病徵極爲相似，故推測可能與本省者爲同一毒素病原（1）。隨後經利用大桔蚜 (*Toxoptera citricidus*) 及嫁接傳播 (Grafting transmission) 於墨西哥雷木 (Mexican lime) 及檸檬 (Lemon) 上，產生典型 Tristeza 之病徵，證實本省柑桔黃龍病爲類似 Tristeza 所引起 (17) 。

Cortez 及 Celino 於非律賓證實 Tristeza 普遍存在於柑桔果園 (8) 。中國大陸柑桔黃龍病 (Yellow shoot) 經 *T. citricidus* 傳播在墨西哥雷木及檸檬上所產生之病徵，認爲該毒素病原與 Tristeza Complex 有關 (10) 。然而本省黃龍病之病原除 Tristeza 外，經臺灣大學蘇鴻基教授證實黃龍病係 Tristeza以及另外一種病因 (Unknown Component) 所引起。本試驗爲瞭解 Tristeza 在本省之分佈情形，並比較外觀健全與罹病柑桔植株在墨西哥雷木及檸檬反應之異同，藉供進一步研究之參考。

二、材料及方法

供試之柑桔植株，選自本省六處柑桔果園，包括不同樹齡、不同品種、外觀健全及罹病植株，詳如表（一）。指示植物墨西哥雷木及檸檬均由種子播種，再移植於 15×18cm 之花缽中，培育於溫室2—3年生，外觀健全，未有顯示任何病徵，以供嫁接之用。

表（一）供試柑桔植株之來源及品種

Table (1)　The sources and species of testing citrus trees.

採集地點 Locality	採集品種 Citrus species	樹齡 Ages	供試棵樹 Test trees	外表觀察 Appearance
石碇 Shih-ting	Tankan	50年生	4	健全
關西 Kuan-hsi	Ponkan	50年生	4	健全
香山 Hsiang-shan	Ponkan	7年生	5	健全
峨眉 O-mei	Tankan	15年生	4	有黃龍病病徵
東勢 Tung-shih	Ponkan	7年生	5	有葉片黃化病徵
天冷 Tein-leng	Ponkan	15年生	4	健全
天冷 Tein-leng	Ponkan	15年生	4	有黃龍病病徵
天冷 Tein-leng	Valencia	15年生	4	有黃龍病病徵

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1 試驗報告農試字第三五二號。2 臺灣省農業試驗所技佐。

所用試驗方法爲（a）雷木反應試驗（Lime reaction）：供嫁接之墨西哥雷木，先切成高約12公分左右，作爲砧木之用。從果園採回之不同柑桔植株，每棵選八接穗，每二接穗嫁接在一棵健全雷木幼苗上，共四重複。爲使接穗快速成活，故用10×18公分之塑膠袋套上，以防止水份過度蒸散，待接穗成活後解開膠袋，觀察新生雷木葉片及枝條呈現之病徵，以供鑑別柑樹之帶毒情形。（b）檸檬反應（Lemon reaction）：從石碇、關西、天冷、峨眉等果園採回植株，每處共嫁接八棵檸檬，每棵二接穗，經2～3個月後，觀察檸檬呈現之反應。

三、試驗結果

從本省果園採回之不同柑桔植株經嫁接於墨西哥雷木及檸檬上，其呈現病徵如表（二）及表（三）。

表（二）利用嫁接接種於墨西哥雷木之反應

Table (2) Responses of graft-inoculated on Mexican lime seedlings.

接穗來源與供試棵數 Locality & No. of test tree	外觀及樹齡 Appearance & Ages	接穗品種 Species of scion	嫁接日期 Date of grafting	觀察日期 Date of observation	觀察結果 (Results)			
					Vein-clearing	Water-soaking	Stem-pitting	Vein-corking
石碇 (Shih-ting)	外觀健全約五十年生 Healthy-looking, about 50 year-old	桶柑 (Tankan)	Feb.26, 1969	Mar. 5, 1970				
No.1					+	+	+	+
No.2					+	+	+	+
No.3					+	+	+	−
No.4					+	+	+	+
關西 (Kuan-hsi)	外觀健全約五十年生 Healthy-looking, about 50year-old	椪柑 (Ponkan)	Mar. 3, 1969	Mar. 5, 1970				
No.1					+	+	+	−
No.2					+	+	+	−
No.3					+	+	−	−
No.4					+	+	+	+
香山 (Hsiang-shan)	外觀健全約八年生 Healthy-looking, about 8 year-old	椪柑 (Ponkan)	Feb.28, 1970	Apr. 6, 1971				
No.1					+	+	+	−
No.2					+	+	−	−
No.3					+	+	+	−
No.4					+	+	−	−
No.5					+	+	−	−
東勢 (Tung-shih)	葉片黃化約八年生 Leaf-yellowing, about 8 year-old	椪柑 (Ponkan)	Feb 13, 1970	Apr. 6, 1971				
No.1					+	+	+	+
No.2					+	+	+	−
No.3					+	+	−	−
No.4					+	+	+	+
No.5					+	+	+	+

天冷 (Tein-leng)	外觀健全約十五年生 Healthy-looking, about 15 year-old	椪柑 (Ponkan)	Feb.28, 1970	Apr. 6, 1971				
No.1					+	+	+	—
No.2					+	+	+	+
No.3					+	+	+	+
No.4					+	+	+	+
天冷 (Tein-leng)	罹黃龍病植株約十五年生 Diseased plant, about 15 year-old	椪柑 (Ponkan)	Feb.26, 1971	Jun.18, 1971				
No.1					+	+	+	—
No.2					+	+	+	—
No.3					+	+	+	—
No.4					+	+	+	—
天冷 (Tein-leng)	罹黃龍病植株約十五年生 Diseased plant, about 15 year-old	晚崙夏 (Valencia)	Feb.26, 1971	Jun.18, 1971				
No.1					+	+	+	—
No.2					+	+	+	—
No.3					+	+	+	—
No.4					+	+	+	—
峨眉 (O-mei)	罹黃龍病植株約十五年生 Diseased plant, about 15 year-old	桶柑 (Tankan)	Mar. 3, 1971	Jun.18, 1971				
No.1					+	+	+	—
No.2					+	+	+	—
No.3					+	+	+	—
No.4					+	+	+	—
溫室 (Greenhouse)	健全幼苗 Healthy seedling	晚崙夏 (Valenica)	Mar. 3, 1971	Jun.18, 1971				
No.1					—	—	—	—
No.2						—	—	—
No.3					—	—	—	—
No.4					—	—	—	—

〔+〕表示病徵已出現。

〔—〕表示未觀察到病徵。

表（三）利用嫁接接種於檸檬之反應

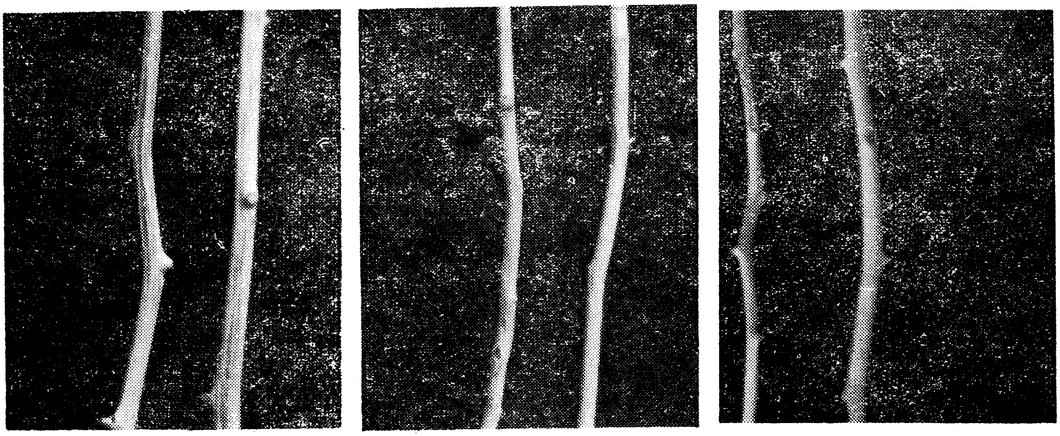
Table (3) Responses of graft-inoculated on lemon seedlings.

接穗來源 Locality of Scion	外表及樹齡 Appearance & Ages	接穗品種 Species of scion	嫁接日期 Date of grafting	觀察日期 Date of observation	黃苗毒素之反應 Responses of seedling yellows virus	病徵 (Symptoms)
石碇 Shih-ting	外觀健全約五十年生 Healthy-looking, about 50 year-old	桶柑 Tankan	Feb.26, 1969	Mar. 5, 1970	+	1 檸檬新生葉片經嫁接2～3個月後可產生黃化，落葉，且比一般健全者狹小。 2 生長受阻，矮化及節間短縮。 3 部份接穗開花異常。

關 西 Kuan-hsi	外觀健全約五十年生 Healthy-looking, about 50 year-old	椪 柑 Ponkan	Mar. 3, 1969	Mar. 5, 1970	+	同上
天 冷 Tein-leng	罹黃龍病植株約十五年生 Diseased plant, about 15 year-old	椪 柑 Ponkan	Feb.26, 1971	Jun.18, 1971	+	1 罹病接穗嫁接於檸檬 2～3 個月後，同樣可產生黃化，落葉，葉面狹小及節間縮短等病徵。 2 從接穗新生葉片，可呈現斑紋，黃化及微量元素缺乏症。 3 部份檸檬呈現恢復之現象。
峨 眉 O-mei	罹黃龍病植株約十五年生 Diseased plant, about 15 year-old	桶 柑 Tankan	Mar. 3, 1971	Jun.18, 1971	+	罹病之桶柑接穗嫁接後所得反應與天冷處同，但未發現檸檬呈現恢復之現象。
對 照 Check	健全幼苗 Healthy seedling	晚 崙 夏 Valencia	Mar. 3, 1971	Jun.18, 1971	−	接穗取自溫室之健全晚崙夏植株，經嫁接後，於檸檬上生長正常繁盛。

〔+〕表示有黃苗毒素存在。

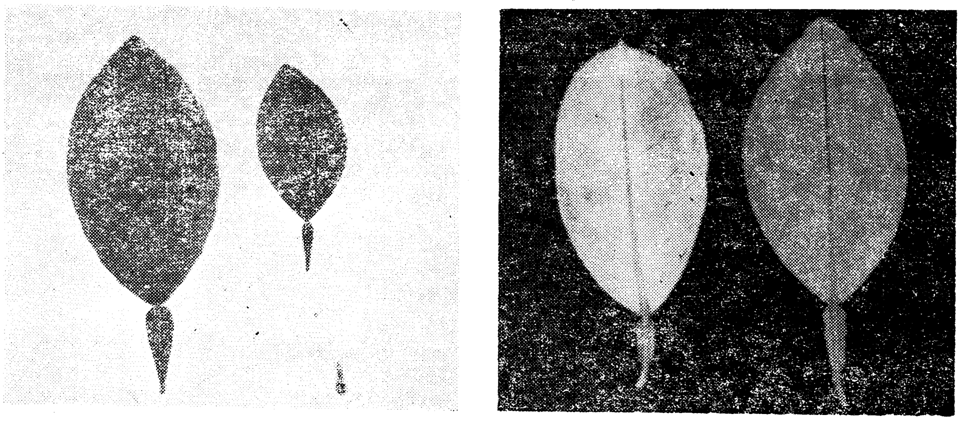
〔−〕表示無黃苗毒素存在。



圖一、Tristeza 在墨西哥雷木枝條上呈現凹陷之病徵。

左：嚴重型病徵。 中：輕微型病徵。 右：健全。

Figure 1. Tristeza stem-pitting on Mexican lime. Left:Severe symptom. Middle:Mild symptom. Right:Healthy control.

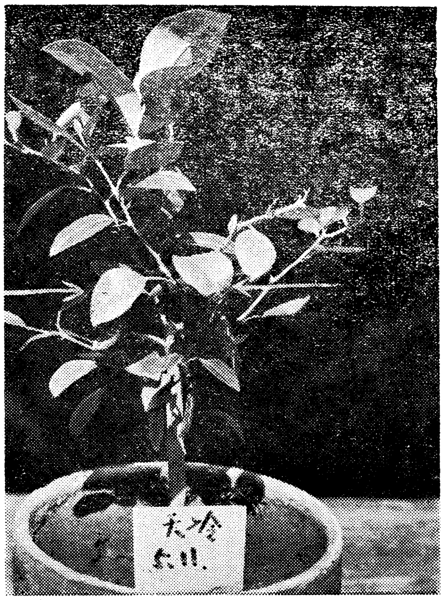


(A) (B)

圖二、Tristeza 在墨西哥雷木葉片上呈現之病徵。

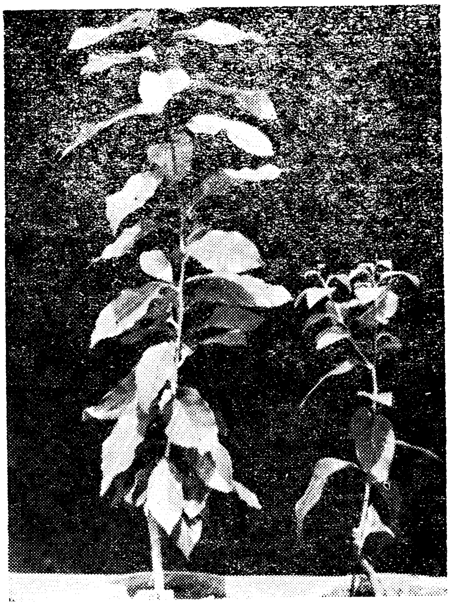
A, 左：健全葉片。 右：葉脈透化。 B, 左：水浸狀病徵。 右：健全。

Figure 2. Symptoms of Tristeza on Mexican lime leaves. (A), Left:Healthy control, Right: Vein-clearing; (B), Left:Water-soaked, Right: Healthy control.



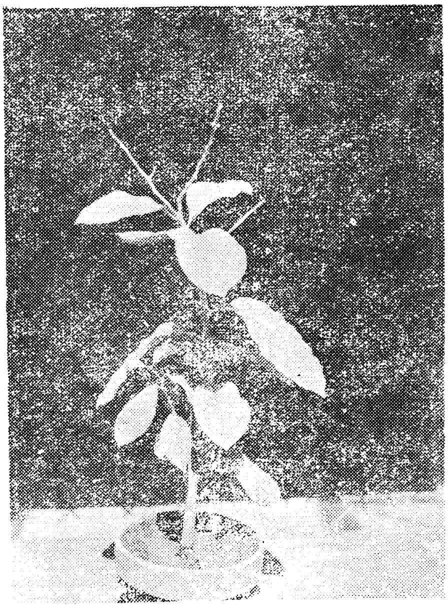
圖三、墨西哥雷木葉片上呈現木栓化病徵。

Figure 3. Vein-corking symptom on Mexican lime leaves.



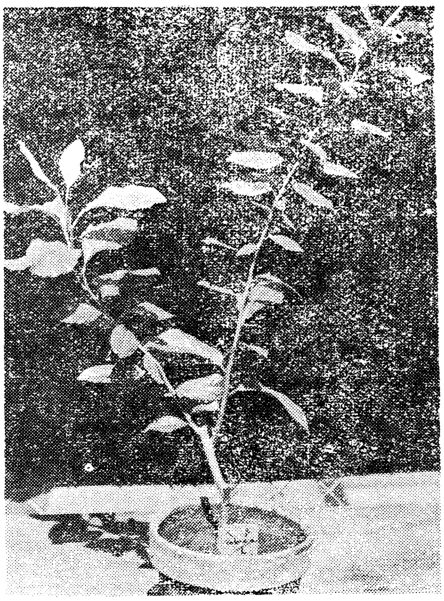
圖四、黃苗毒素在檸檬上經 2 個月後呈現之病徵。(左：健全，右：罹病）。

Figure 4. Seedling yellows symptoms on lemon, 2 months after graft inoculation. (Left: Healthy control. Right: Diseased plant).



圖五、黃苗毒素經嫁接後一年在檸檬上未呈現恢復現象。

Figure 5. Seedling yellows showing on lemon 1 year after inoculation without recovery.



圖六、黃苗毒素經嫁接後四個月在檸檬上呈現恢復現象。

Figure 6. Seedling yellows-affected on lemon 4 months after inoculation exhibited recovery.

由表（二）、表（三）之結果，可知採自六處柑桔果園之不同柑樹，不論接穗（Scion）採自外觀健全或罹病之柑桔植株，經嫁接傳染於指示植物墨西哥雷木及檸檬上，都可產生相似之反應。雷木葉片顯然呈現葉脈透化（Vein-clearing）（圖二，A），水浸狀（圖二，B）及木質部凹陷（Stem-pitting）（圖一）等病徵，因此可證實 Tristeza 普遍存在於臺灣柑桔果樹中。接穗來源不同，雷木矮化或凹陷之程度亦有差異，有時可發現雷木葉片產生木栓化病徵（圖三）。

從嫁接約 2 個月後之檸檬新生枝葉觀察，葉片比正常者狹小、萎縮，且有黃化現象，其枝條則矮化、頂部落葉以及節間縮短等病徵（圖四、圖五），顯示不論外觀健全或罹病柑桔植株均有黃苗毒素（Seedling yellows virus）之存在。接穗來源不同，檸檬間反應亦有差異，接穗取自石碇或關西之柑樹，經嫁接於檸檬，未有恢復現象（圖五），但取自天冷者，經四個月後部份檸檬呈恢復現象（圖六）。

四、討　　論

本試驗乃進一步瞭解 Tristeza 毒素病原在臺灣果園存在之情形，從雷木產生之病徵，證實外觀健全之柑樹本身是一種無病徵携帶者（Symptomless carrier）。根據南美報告，利用酸桔（Sunki、廣東檸檬（Rampur lime）爲砧木，對當地 Tristeza 呈現抗病性（18、19）。然而本省果園已普遍用此兩種品種爲砧木，但罹病率仍然極高，究屬不同病原，抑有其他病原存在則亟待解決。無論接穗採自健全或罹病植株，雷木上反應除呈現 Tristeza病徵外，在較老葉片上尚可出現木栓化（Vein-corking）病徵。 Olson 謂此種病徵與缺硼所導致之分裂症（Splitting）極爲相似，但分析病葉組織却無顯示缺硼症，因此推測可能是植物環境與毒素感染之反應，或根系及韌皮部被毒素侵入損壞，產生第二次病徵（21）。

在檸檬上之病徵似與中國大陸報告之柑桔黃龍病（Yellow shoot）由 Tristeza-complex 引起者極爲相似（10）。Mclean 及 Plank 謂黃龍病之病原爲複合型（Tristeza virus complex），包括陷莖毒素病（Stem-pitting）及黃苗毒素病（Seedling yellows）（2,12,16）。陷莖毒素可在雷木上產生木質部凹陷，而黃苗毒素則引起檸檬黃化及矮化。Wallace 認爲檸檬從黃苗型病徵恢復，顯然是由一種黃化毒素（Yellow-inducing virus）或該毒素與 Tristeza 所致（23）。然而亦有認爲由 Tristeza 之不同病原型（Strain）所引起（9,14,15,21）。Knorr 及 Price謂陷莖、黃苗及黃龍病病原係同一種毒素之不同病原型（2,16）。當利用高熱處理法（Heat treatment）可分離出三種病原型，即極輕型（Very mild）、輕微型（mild）及嚴重型（severe），若以極輕型嫁接在檸檬上，並無明顯病徵出現，輕型則產生矮化，但有恢復現象，而嚴重型則使檸檬產生矮化、黃化及雀斑（Flecking）之病徵（2,14,15）。Desiardins 等用熱處理亦獲相同結論（9）。總之，該病原性質有待於進一步分離與澄清，而陷莖毒素及黃苗毒素病原存在於本省，則無可置疑。

從外觀健全與罹病柑桔接穗新生葉片之比較，病穗葉片可產生黃化及微量元素缺乏症，而健全者則無。此種病徵在晚崙夏（Valencia）幼葉更爲明顯。雷木葉上偶爾亦可發現類似之病徵，但成熟後即行消失，這種病徵與外國報告之 Stubborn (5, 6, 7) 及 Greening (13, 20, 22) 病害所引起病徵極爲相似。Fraser從酸橙及一些指示植物上所產生病徵之差異，認爲除 Seedling yellows-Tristeza 外，可能有 Greening 之存在（12）。本省柑桔黃龍病，據臺灣大學蘇鴻基教授言，已證實爲 Greening，其病原係 Mycoplasma所致。因此，對於病原生理之探討，乃爲急迫之需求，然後始可研究有效防治效果。

五、摘　要

採自外觀健全與罹病柑桔植株之接穗，經嫁接於墨西哥雷木上，均可產生 Tristeza 典型病徵，偶爾可在較老葉片上出現木栓化病徵。檸檬上產生葉片黃化、落葉、葉片狹小及節間縮短等病徵，顯示 Tristeza 毒素病原已普遍存在於臺灣柑桔園中。

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STUDIES ON CITRUS VIRUS DISEASES IN TAIWAN

1. Reactions of Mexican Lime and Lemon to the Apparently Healthy and Diseased Scions of Citrus Trees in Taiwan

by

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SUMMARY

The purpose of this study is to realize the similarities and differences of reactions between the healthy-appearance and diseased-appearance of citrus trees on Mexican lime and lemon. Preliminary results found that both apparently healthy scion and diseased scion grafted on Mexican lime exhibited the symptoms of tristeza disease, such as vein-clearing, water-soaking, stem-pitting and smaller leaves on lime. Under this study it is not unusual vein-corking was found in older leaves. When these two different scions were grafted on lemon, the symptoms of seedling yellows were shown after 2-3 months. Therefore, it could be sure that tristeza virus exhibits in both healthy-appearance citrus trees and diseased-appearance citrus trees in Taiwan.

It was also found that most newly developing leaves from diseased scions is different from that of apparently healthy scions. In advanced observations, these newly developing leaves of the former showed the symptoms resembling the deficiency of iron or manganese element after 3-4 months. It also showed severe yellowing, stunting and smaller leaves. The symptoms of micro-element deficiency were more clearly when the diseased scions were grafted onto Valencia species. The diseased plant that called Huanglungpin may suggest the presence of another agent, probably greening disease, in addition to seedling yellows-tristeza.